

1. Department, Course Number, and Course Title:

MECHANICAL ENGINEERING

ME 423 INTRODUCTION TO THE FINITE ELEMENT METHOD

2. Designation: Required Elective
Lower Division Upper Division

3. Course Description: Derivation of element stiffness matrices for spring, bar, beam, and constant-strain triangle elements, from energy principles. Application to trusses and frames. Steady-state heat transfer. Use of finite element method software.

4. Prerequisites: CE/ME 210 (Matrix Algebra for Engineers), CS 290 (Introduction to FORTRAN Programming), MATH 215 (Differential Equations), Corequisites: ME 306 (Heat Transfer I), ME 323 (Machine Design I).

5. Text and Materials: A First Course in the Finite Element Method, 3rd Ed., D. L. Logan, Brooks/Cole, 2002

6. Course Objectives: Seniors in Mechanical Engineering will learn and understand the concepts and principles, and methods of analysis, followed in the displacement, or stiffness, approach within the finite element method, to model and simulate deformable bodies under loading, and heat transfer processes.

Course Outcomes

- Ability to carry out the conceptual and computational steps followed in the displacement, or stiffness, approach, within the finite element method, to model bodies and simulate deformation processes, the steps being: body discretization, element shape function selection, element stiffness matrix development, specification of loads and boundary conditions, and assembly and solution of governing force-displacement matrix equations.
- Ability to carry out analogous steps for steady-state heat transfer.
- Ability to derive element stiffness matrices for linearly elastic spring, bar, beam, and constant-strain triangle elements, from the principle of stationary potential energy.
- Ability to assemble element stiffness matrices to represent three-dimensional trusses, two-dimensional frames, and plates.
- Ability to formulate loads and boundary conditions for truss and frame structures, and plane-strain and plane-stress problems, and incorporate them into the governing force-displacement matrix equations.
- Ability to solve the governing force-displacement matrix equations, by hand calculations, or with mathematical software, or commercial FEM software.
- Ability to extract element stress information.
- Awareness of the complexities and limitations of the finite element method.
- Ability to apply concepts and methods of analysis from the finite element method to homework problems.
- Ability to solve steady-state heat transfer problems with commercial FEM software.

7. Topics Covered: (in Order of Presentation)

- Introduction. History, applications, advantages, and limitations of FEM. Steps of FEM. Computer programs for FEM.
- Introduction to the Stiffness (Displacement) Method
- Development of Truss Equations
- Development of Beam Equations
- Development of Frame Equations
- Two-Dimensional Elements
- Modeling Guidelines Using the CST Element as an Example
- Steady-State Heat Transfer

8. Class Schedule: Number of Sessions per week: 2
Duration of each session: 1 hour 40 minutes

9. Contribution of course to meeting the professional component:

This course is part of the 25 units of upper division technical electives required for the mechanical engineering program.

Engineering Science

4 units

10. Relationship of course to program objectives:

This course relates to the program objectives by contributing to the following measurable outcomes at the level indicated for all engineering graduates:

Knowledge outcomes:

- an ability to apply knowledge of mathematics, science, and engineering (abet a)
- an understanding of professional and ethical responsibility (abet f)
- a knowledge of computer aided design and simulation software
- a knowledge of how mechanical engineering integrates into inter-disciplinary systems

Skill outcomes:

- an ability to communicate effectively (abet g)
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (abet k)
- an ability to think in a logical sequential process

Attitudes Outcome:

- a recognition of the need for an ability to engage in lifelong learning (abet i)
- an understanding of responsibility and accountability
- a desire to be a professional that exhibits values, dedication and a need for continual improvement

11. Prepared by:

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05/2005